

HUGHES INSTRUMENTS



INTEGRATING
DIGITAL VOLTMETER
MODEL 5000 A

HUGHES

HUGHES AIRCRAFT COMPANY

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HUGHES MODEL 5000 A

DIGITAL VOLTMETER

A NEW DESIGN CONCEPT IN DVM CIRCUITRY

In contrast to conventional digital voltmeters which use bridge circuits to obtain a digital readout of the applied voltage, the electronic break-through represented by the HUGHES DVM employs unique voltage-to-frequency conversion circuitry. The result is a totally new and fully integrating digital voltmeter. Our DVM is an all electronic, solid state, five-digit instrument with extreme accuracy and reliability.

Study of the diagram below will reveal that the voltage-to-frequency conversion circuitry with a self-correcting network is an advanced state of the art instrument. The HUGHES INSTRUMENTS design allows the use of very few critical components.

The input signal is coupled through an attenuator to a potentiometric amplifier to provide a constant high impedance to the input voltage. The amplifier is chopper stabilized for extreme stability, and has a booster circuit for fast rise time, resulting in a sensitivity of $100 \mu\text{V}$ over the full $\pm 10\text{V}$ dynamic range of its output.

The input amplifier output is coupled to the Voltage Controlled Oscillator whose output frequency at 2 MC corresponds to zero voltage applied to the input. The frequency range of the VCO is 1 MC to 3 MC. The VCO and integration amplifier circuit are the heart and bloodstream of the HUGHES INSTRUMENTS DVM.

A frequency to voltage comparator detects drift and non-linearity of the VCO and applies a correction signal at the rate of 100 to 300 times per second. Precision resistors R_1 and R_2 and capacitor C_1 , along with transistorized switches S_1 and S_2 , not only tell the Voltage Controlled Oscillator what error, if any, exists, but also provide corrections rapidly.

The integrator network compares the input voltage to the VCO output frequency. If the VCO frequency is not correct, the integration network sends the VCO a correction signal of the proper polarity.

For purposes of explanation, assume any input voltage to the HUGHES DVM. In this condition there is a constant current fed to the integrator amplifier from the junction of R_1 and R_2 . This current is controlled by the applied voltage and the negative reference voltage. It is this current which determines the rate of charge of C_1 , i.e., the slope of the sawtooth voltage at TE 3. The charging time of C_1 is dependent upon the time between reset pulses from the Reset Generator. The pulse rate of the Reset Generator is determined by the VCO. The average voltage (ramp) of the integrator output is always constant for any applied voltage, if the VCO frequency is correct. Under this condition, a portion of the reference voltage is used to offset this average voltage through voltage divider R_4 and R_5 . The result is zero voltage at TE 4.

When there is a frequency error, there is also an erroneous ramp voltage at TE 3, and an error indicating voltage at TE 4. The error voltage is amplified and fed back to the VCO.

At TE 6 the VCO frequency is exactly proportional to and in effect represents the applied voltage. This signal is fed to the crystal controlled gate which remains open exactly 100 milliseconds and is closed approximately 14 milliseconds, at the fastest readout display time.

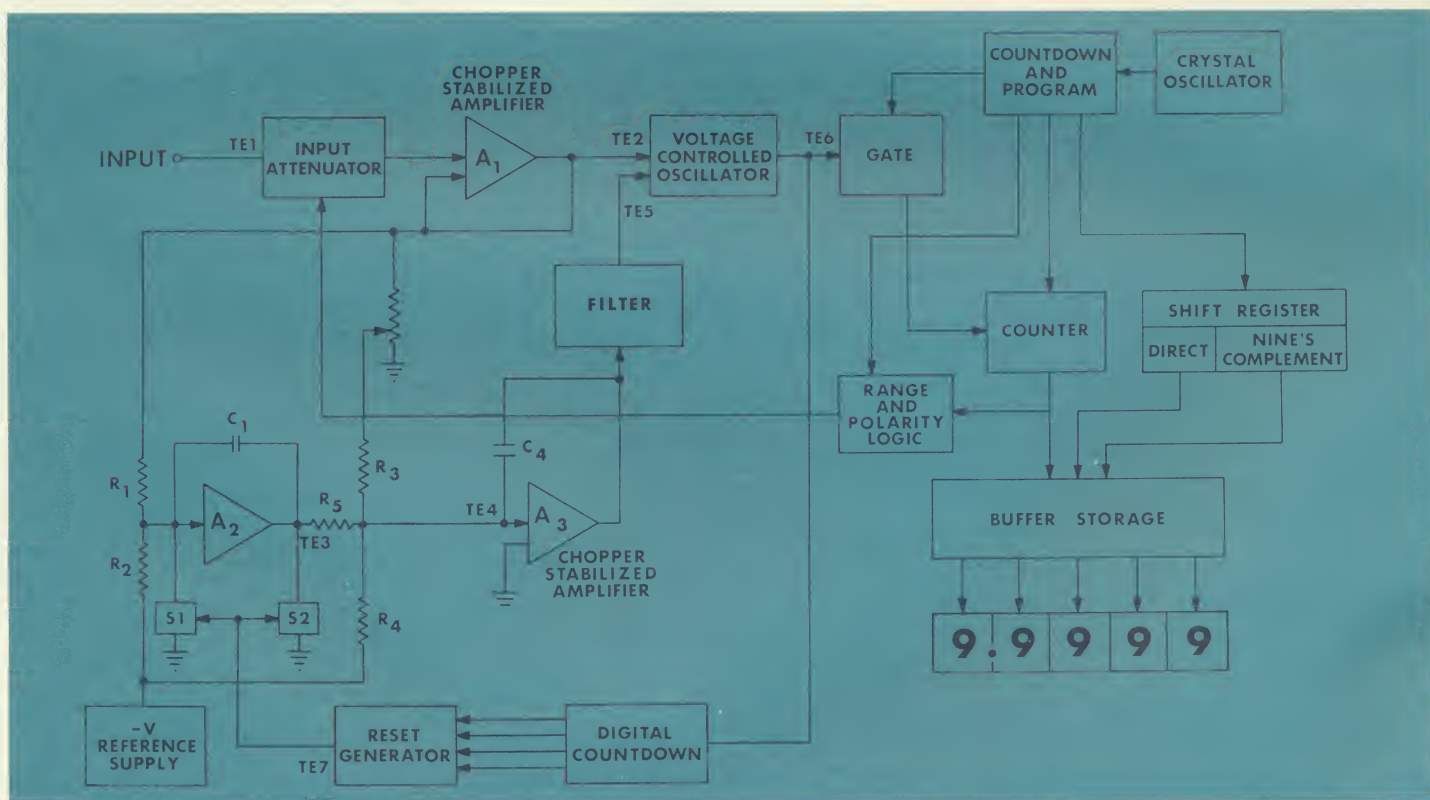
The "Countdown and Program" portion shown in the block diagram is composed of a system of flip-flop circuits that function as a frequency sensor device. By means of nine's complement circuitry, range and polarity are automatically selected. The Shift Register determines whether the readout will be direct or by nine's complement.

The Buffer stage relays all the information to the long-life Nixie lights and to Model 5000 A Printer Driver boards when auxiliary recording equipment is used with the DVM. The Buffer stage also stores the information while the next reading is being taken by the instrument.

Additional features of the HUGHES Digital Voltmeter which enables it to provide fast, averaging, full-time, five-digit readout include:

1. The 0.1 gate time assures cancellation of AC noise in multiples of 10 cps.
2. The range selector positions the decimal point depending on the most significant digit of the frequency count.
3. The frequency counter is a six-decade unit which counts the output of the VCO. Example frequencies for three input voltages are: +10 volts equals one megacycle; 0 volts equals two megacycles; and -10 volts equals three megacycles.
4. A brightly lighted OVERLOAD sign automatically turns on if a manually selected range is too low for the input voltage.

The HUGHES INSTRUMENTS DVM is a highly accurate and dependable integrating type digital voltmeter that will give you years of trouble-free service.



ACCURACY, DEPENDABILITY, VERSATILITY ALL COMBINED IN THE HUGHES DVM

The HUGHES INSTRUMENTS Model 5000 A Digital Voltmeter is the most advanced state of the art five digit integrating DVM available on the market today. It is a solid state, all electronic, precision-built digital voltmeter, that is fully programmable, with remote control capability. Additional benefits include extremely versatile printer driver combinations. The instrument can also be used with auxiliary equipment for AC and Ohms measurements.

It took a new and bold approach in the electronic circuitry design field to produce the HUGHES INSTRUMENTS DVM concept for which a patent has been applied. Our new and unique design, considered an important engineering breakthrough, is more fully described on the previous page, along with a simplified block diagram.

Circuitry advancements are of little consequence unless the instrument actually produced fulfills an industry and/or military need, and is marketed at a competitive price. We believe you will find our instrument more than adequately meets all the requirements.

For instance, rapid readout of a DVM is of little value unless accompanied by extremely high degrees of accuracy, linearity and resolution. These important characteristics are inherent in the basic design of the HUGHES INSTRUMENTS Model 5000 A Digital Voltmeter. With laboratory precision, our DVM is capable of at least 9.9 readings per second (variable to 15 seconds per reading) while maintaining an accuracy of 0.01% of reading, $\pm 0.002\%$ of full scale; a resolution of 0.001%; and a linearity of 0.005%. There is a counter ambiguity of 1 digit. Automatic range and polarity switching are additional features of the HUGHES DVM.

A visual inspection of the instrument along with a practical demonstration of its capabilities are the best ways to determine how the unit can fulfill your specific digital voltmeter requirements. Contact the HUGHES INSTRUMENTS representative in your area or contact us direct for a complete demonstration of the unit and a full discussion on our new instrumentation concept. The investment for the best all around digital voltmeter on the market today, the HUGHES INSTRUMENTS DVM Model 5000 A, is only \$2,795.

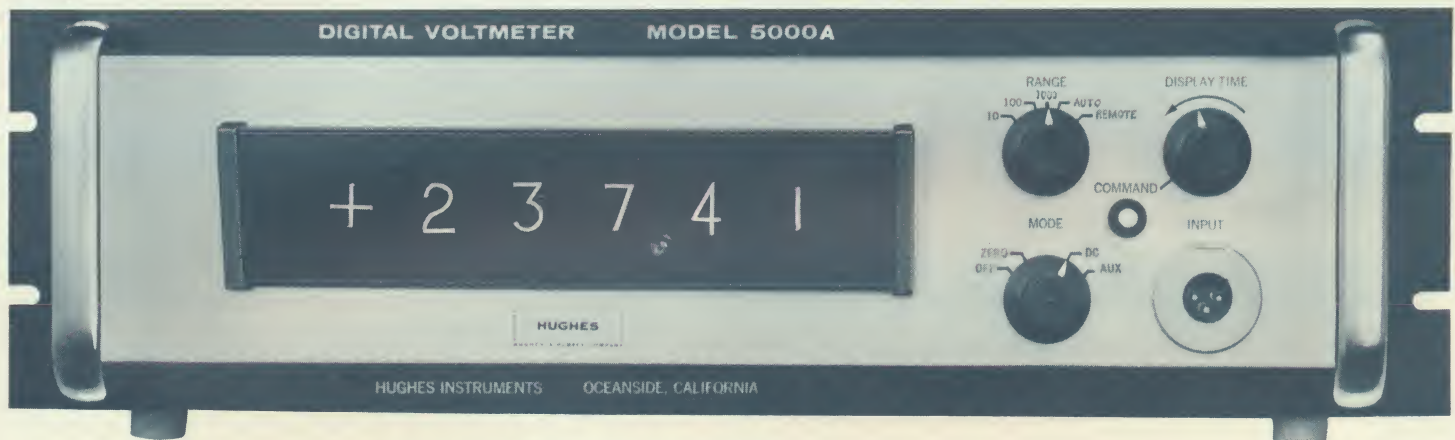
ANOTHER FEATURE IS PRINT-OUT CAPABILITY

The HUGHES INSTRUMENTS Model 5000 A Digital Voltmeter, in addition to ordinary DVM functions, has extremely versatile printer driver capabilities including complete remote control programming. You purchase only those plug-in printed circuit boards which fulfill your print-out requirements. And, if in the future your requirements change, you can secure additional boards to keep your HUGHES DVM at maximum useability. All printer driver boards are easily plugged into the DVM without factory modification. Space is provided in the unit to accept all optional boards.

Our printer driver boards will provide binary code group signals for any system accepting True or False type information for the following three logic levels: (1) 0 at ground and 1 at +10 volts; (2) 0 at +10 volts and 1 at ground; and (3) 1 at ground and 0 at -10 volts. For these three logic combinations, there is also a ten-line decimal output available at the same time. In this system, 1 level is at ground and 0 level is +60 volts into a 500 K load. A fourth logic level, 0 at ground and 1 at -10 volts, is available for BCD systems using either 1-2-4-8 or 1-2-2-4 code combinations.

The "Read Command" as given to the digital voltmeter by your printer can be either a contact closure to ground, or a positive-going pulse with 10-volt amplitude and 10 microseconds durations or longer. The "Print Command" as given to the printer by the DVM must be specified when ordering the Model 5000 A digital voltmeter. You can designate either a positive or a negative 10-volt pulse.

Remote programming capability is a standard feature in all Model 5000 A units. Remote control is accomplished by contact closure to ground. Functions which may be programmed from the rear panel connector are range, command, AC, DC, and resistance measurements. HUGHES INSTRUMENTS welcomes the opportunity to consider your specific print-out requirements in order to help you achieve the results you desire.



OHMS AND AC MEASUREMENTS

The versatility of the HUGHES INSTRUMENTS Model 5000 A Digital Voltmeter is enhanced by the capability of mating with our Converter Power Supply Model 1600. This power supply provides space for our AC Converter Model 1100, and Ohms Converter Model 1200. And, like the printer drive feature of our DVM, ohms or AC measurements can be programmed and controlled remotely.

The plug-in AC Converter easily handles a frequency range of 30 CPS to 10 kc with an accuracy of plus or minus 0.1% of reading or two digits. Good accuracy is maintained to 300 kc. The unit's input impedance is 10 megohms, and it has a resolution of 100 μ v. AC measurements can be made with the input circuit fully floating.

Our Ohms Converter, which also fits into the accessory power supply, simultaneously with the AC Converter, is based on a unique and advanced design. This concept allows measurements of resistances at relatively low current levels while also decreasing stray pickup.

The plug-in AC Converter, Model 1100, can also be used with Accessory Power Supply Model 1610 to expand the capabilities of our Model 5100 Digital Voltmeter.

OPERATION — SERVICE — MAINTENANCE

The HUGHES Digital Voltmeter is designed for a minimum of operator training. All controls are conveniently located on the front panel and protective circuitry and automatic operation capability virtually eliminate operator error which could damage the instrument.

In addition, the polarized bezel covering the Nixie readout lights can be adjusted to facilitate greater ease in reading the unit's output, thus reducing operator fatigue.

It is also important to note that even when the instrument is being operated manually as well as in "Automatic" or "Remote" positions, a lighted "OVERLOAD" sign is displayed if the input is too high for the range selected. The OVERLOAD sign remains lighted until the proper range is selected or the high input voltage is removed.

Modular construction throughout the instrument provides quick and easy service and maintenance, should any of the circuits or components need to be replaced. There are only a few critical components in the HUGHES DVM, and these are all easily accessible.

A VARIETY IS OFFERED

For those who do not require the extreme versatility of the Model 5000 A Digital Voltmeter, we also produce an equally fine and accurate five-digit DVM known as the Model 5100.

The Model 5100 is based on the same advanced circuitry and has all the features of the Model 5000 A except printer driver boards and Ohms measurement capability. Our Converter Power Supply Model 1610, and AC Converter Model 1100 are ideal optional units for use with the Model 5100 Digital Voltmeter.

INVESTMENT FIGURES

DVM, Model 5000 A.....	\$2795
DVM, Model 5100.....	\$2695
Aux. Power Supply, Model 1600 (For use with 5000 A DVM)....	\$ 425
Aux. Power Supply, Model 1610 (For use with 5100 DVM)....	\$ 395
AC Converter, Model 1100 (Must use one of the above power supplies).....	\$1050
Ohms Converter, Model 1200 (Must use the 1600 power supply) ..	\$1100
Printer Driver Plug-in Boards (Prices quoted on receipt of your requirements)	



COMPARE THE ADVANTAGES

Compare the advantages of the HUGHES INSTRUMENTS Model 5000 A Digital Voltmeter with any other DVM on the market today:

- Full time, five-digit readout with an accuracy of 0.01% of reading or $\pm 0.002\%$ of fullscale, with a counter ambiguity of 1 digit.
- Optional plug-in printer driver boards to meet your binary code or decimal system requirements.
- Plug-in modular construction for ease and speed in maintenance. Only a few critical components in the entire unit.
- Capable of mating with an auxiliary power supply and converters for AC and Ohms measurements.
- All electronic, solid state construction for compactness, lightness and extremely long life and trouble-free operation.
- Removable front panel "ears." With the brackets in place the unit can be used in a conventional 19-inch rack. With the "ears" off the instrument is a convenient bench type unit.
- The HUGHES Model 5000 A is programmable including full remote control.
- The circuitry is based on a new and advanced concept. An input filter is not required because of the integrating nature of our DVM. AC normal mode noise rejection is a minimum of 60 db at 60 cps. Common mode rejection is 110 db at 60 cps.
- Display time can be adjusted by a front panel control to allow a wide variation in reading speed. Command readings are also readily available.
- Although precision built for scientific laboratory measurements, the HUGHES DVM is rugged enough for use in the field.
- Volume purchasing of carefully selected components; advanced production line techniques, plus rugged Quality Control assure you of receiving a highly reliable unit for the nominal investment of only \$2795 for the basic instrument. Optional equipment is equally low priced.

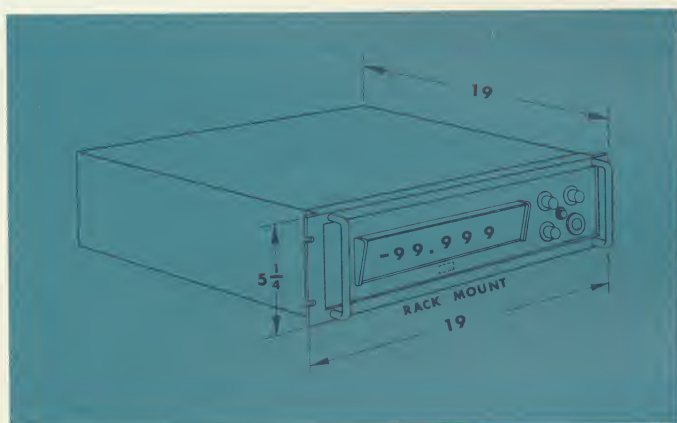
For additional information or demonstration ...
write, wire or call:

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MODEL 5000 A SPECIFICATIONS

Decimal Digits	5
Ranges	$\pm 9.9999 / 99.999 / 999.99$ Volts DC, automatic or manual range selection, automatic polarity changing.
Sensitivity	100 μ V
Accuracy	0.01% of reading, or $\pm 0.002\%$ of F.S.
Resolution	0.001%
Linearity	0.005%
Counter Ambiguity	0.001%
Display Time	Variable — .1 sec. to 15 sec.
Readings	9.9/sec. to 15 sec./reading
Input Impedance (constant).....	1000 megohms on 10 V scale; 10 megohms on 100 V and 1000 V scales.
Above Ground Measurements	0 to 500 volts.
Readout	Nixie lights, adjustable bezel.
Common Mode Rejection	120 db at DC; 110 db at 60 CPS
Normal Mode Rejection	60 db min. at 60 CPS with no input filter.
Temperature	+10°C to 43°C
Dimensions	19" x 19" x 5 1/4" rack mount; 17 1/4" x 19" x 5 1/4" portable.
Weight	32 pounds
Power	115/230V, $\pm 10\%$; 50 to 60 CPS; 110 watts

(Prices and specifications subject to change without notice)